Curtailing Room Temperature to Ambient Temperature: Impact on Environment, Energy Consumption, and Personal Comfort

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Abstract: *Curtailing room temperature to ambient temperature has a significant impact on our environment, energy consumption, and personal comfort. Ambient temperature could be defined as the temperature of the surrounding area or the external environment. By reducing room temperature to match the ambient temperature, the use of artificial cooling or heating systems, such as air conditioners or heaters can be minimized. The research developed an automated system using an ESP8266 Microcontroller, DHT11 Temperature Sensor, 5V Relay Module, Fan, and Power Supply to control room temperature by comparing room and ambient temperatures and adjusting fan operation accordingly for energy conservation, environmental, economic, and comfort-related benefits of aligning room temperature with ambient temperature. Room temperatures were highest in R1 (three users) at 34.33°C (PM) and 34.25°C (AM), indicating user presence maintains heat. R2 (two users) had slightly lower temperatures at 33.81°C (PM) and 33.33°C (AM), showing fewer users generate less heat. R3 (no users) showed significantly lower temperatures at 26.87°C (PM) and 26.35°C (AM), highlighting that absence of users leads to lower heat accumulation. ANOVA results show a significant effect of room conditions on temperature but no significant effect of the time of day. The Duncan Multiple Range Test indicates notable differences between room temperatures, affirming that user presence is a dominant factor in temperature variation.*

Key Words: *Environment, Energy, Consumption, Personal, Comfort.*

Introduction / Background Study

In modern society, the use of artificial cooling and heating systems is pervasive (Khosla et al. 2022). While these systems provide comfort, they also consume significant amounts of energy and contribute to greenhouse gas emissions (Khosla et al. 2022; John et al. 2023). Reducing room temperature to align more closely with ambient temperature presents an opportunity to conserve energy, reduce environmental impact, and lower utility costs (Aghniaey et al. 2019; Qiang et al. 2023). This study presents research on an automated system designed to maintain room temperature at ambient levels. Energy conservation is one of the primary benefits of reducing room temperature to ambient levels (Ma et al. 2021). Heating and cooling of building are major consumers of electricity and fossil fuels (Holechek et al. 2022). By curtailing their use, energy demand can be reduced (Mohammadalizadehkorde and Weaver 2020; Mafimisebi 2023). This reduction in energy consumption directly translates into lower greenhouse gas emissions, contributing to the mitigation of climate change and promoting sustainability (Prada et al. 2020) .Lower energy consumption results in reduced utility bills, offering economic advantages for both individuals and organizations (Maradin 2021). The cumulative effect of widespread adoption of this practice can lead to substantial savings and resource conservation. The economic benefits are particularly relevant in regions with high energy costs or where energy efficiency is a priority. Maintaining a balance between environmental impact and personal comfort is essential (Jay et al. 2021). While reducing room temperature to ambient levels may require adjustments, it can also enhance comfort by creating a more natural living environment. Additionally, the use of automated systems can ensure that temperature adjustments are made seamlessly, maintaining comfort without manual intervention (Chaudhary et al. 2021; Spirig et al. 2021; Velkova et al. 2022; Wu 2022).

Wu (2022) designed a smart home-based control system using Arduino Uno and sensors to automatically adjust air conditioning for optimal comfort and energy efficiency, addressing health impacts of thermal comfort and high energy consumption in air conditioning. However the study did not considered ambient temperature conditioning. Manivannan and Radhakrishnan (2023) proposed an autonomous fan speed controller that adjusts based on temperature using an Arduino microcontroller and embedded technology, providing efficient and reliable control with a compact design and applications across various appliances and industries. The study did not cover temperature conditioning for home comfort. Khaing et al. (2020) proposed automatic temperature control system using an Arduino Uno-based microcontroller and LM35 temperature sensor for modern gadgets and smart homes, offering efficient temperature regulation and display via PWM on an LCD screen. The study however did not monitor temperature nor control room temperature to the ambient temperature. ObiefuNa et al. (2021) observed that land surface temperature (LST) and land cover change in Lagos State, Nigeria, using Landsat imagery from 1984 to 2019, revealed significant urban sprawl, increased mean LST by 2.16°C, and strong links between high LST and urban areas, highlighting the need for urban development policies focused on green infrastructure and carbon sequestration. Tajuddeen and Rodrigues (2024) noted that Sub-Saharan Africa faces severe overheating due to poorly constructed buildings and costly energy services, exacerbated by global warming. And it evaluates the impact of design parameters on cooling energy demand in small office buildings in Lagos and Kano, Nigeria, revealing that future cooling loads will increase significantly, with thermal conductivity and solar absorptance of building elements being the most influential factors.

Materials and Method

The research involved the development of an automated system to control room temperature. The entire process is outlined in the form of flowchart shown in Figure 1. The system components included ESP8266 Microcontroller, DHT11 Temperature Sensor, 5V Relay Module, Fan, Power Supply. The system was initialized by setting up these devices. The temperature sensor measured the surrounding temperature, and the fan operated based on the comparison between the room and ambient temperatures. The temperature sensor was used to measure the room temperature at various times of the day. The microcontroller processed the data and controlled the fan operation. The fan cooled the room and reduces the room temperature when the temperature exceeded the preset threshold and also stopped when the temperature was below the threshold.

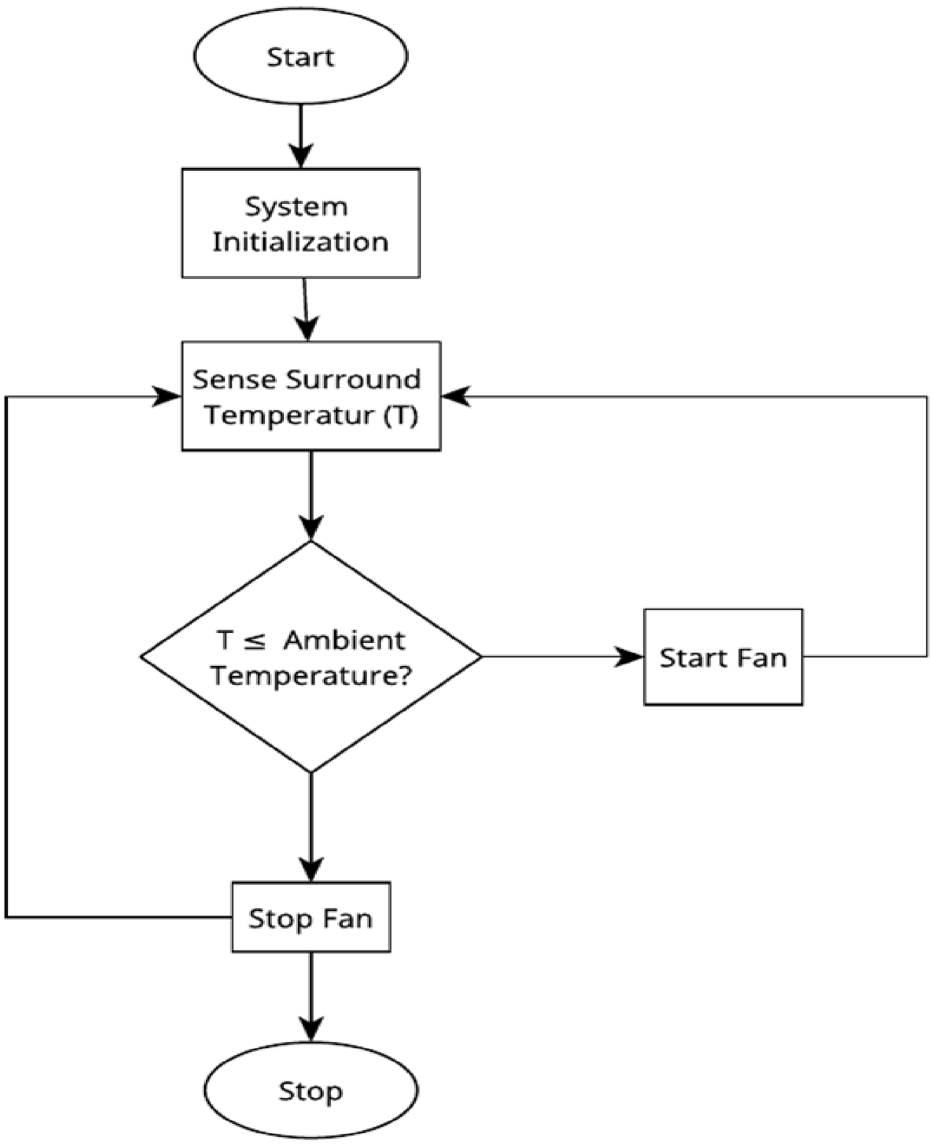

Figure 1. Flowchart to control room temperature

Results and Discussion

Table 1 present temperature measurements in three different room conditions during AM (8 to 11) and PM (12:30 to 7:30) periods.

Table 1. Mean effect of room temperature measurements

Day	R1	R2	R3
PM (12:30 to 7:30)	34.33	33.81	26.87
AM (8 to 11)	34.25	33.33	26.35

Where R1= Room Temp °C with 3 users; R2 = Room Temp °C with 2 users; R3= Room Temp °C with no user

The rooms differ by the number of users present: R1 with three users, R2 with two users, and R3 without any users. Room R1 contained 3 users having temperature of 34.33°C at PM and 34.25°C at AM. The temperature remains relatively stable with minimal variation between AM and PM. This indicates that the presence of three users contributes to maintaining a consistent heat level within the room, regardless of the time of day**.** Room R2 contained 2 users with temperature 33.81°C at PM and 33.33°C at AM. Similar to Room R1, Room R2 also shows a slight decrease in temperature from PM to AM. However, the overall temperature is slightly lower than in Room R1, suggesting that fewer users contribute less to heat generation. Room R3 with no user having the temperature of 26.87°C at PM and 26.35°C at AM. Room R3 exhibits significantly lower temperatures compared to R1 and R2. The absence of users leads to a substantial drop in heat accumulation. The slight decrease in temperature from PM to AM is in consistent with typical cooling patterns during the night as reported by ObiefuNa et al. (2021).

The presence of users has a marked impact on room temperature. Rooms with more users tend to retain higher temperatures, indicating that human activity and body heat contribute significantly to the overall heat level. While the time of day affects temperature slightly, user presence is a more dominant factor. Both R1 and R2 show similar patterns with marginal temperature differences between AM and PM. The result suggests that in rooms with higher user density, cooling systems may need to work harder to maintain a comfortable temperature. Conversely, rooms without users naturally stay cooler, reducing the need for active cooling. Ensuring comfort in occupied rooms may require more efficient cooling solutions or adjustments in cooling schedules to align with peak usage times. Automated systems can play a crucial role in optimizing temperature control for energy efficiency and comfort. Table 2 shows the results of the ANOVA and indicate a significant effect of room conditions on temperature, but no significant effect of the time of day.

Table 2: The results of the ANOVA test on rooms and users available

Predictor (Temperature)	Sum of Squares	df	Mean Square	F	p
Day	0.8	1	0.8	0.59	0.45ns
Room	288.01	2	144	106.76	0.01*
Day x Room	0.24	2	0.12	0.09	0.92ns
Error	24.28	18	1.35		

The results of the Duncan Multiple Range Test shown in Table 3 revealed significant differences between room temperatures.

Table 3: The results of the Duncan Multiple Range Test on rooms and users available

Room Condition	Temperature (°C)
AM	31.31 ± 3.79a
PM	31.67 ± 3.75a
R1	34.29 ± 0.96a
R2	33.57 ± 0.68a
R3	26.61 ± 1.5b

The results demonstrate that curtailing room temperature to ambient levels can significantly reduce energy consumption and provide economic benefits. The automated system effectively maintained room temperature within desired limits, ensuring comfort while conserving energy. This is line with the report that thermal conductivity and solar absorptance of building elements are the most influential factors that will reduce energy consumption and provide economic advantage (Tajuddeen and Rodrigues 2024).

Conclusion

The results of the analysis highlight the relationship between user presence, time of day, and room temperature. Rooms with more users retain higher temperatures, requiring more energy for cooling. Conversely, rooms without users naturally stay cooler, presenting opportunities for energy conservation. Automated temperature control systems can effectively manage these variations, enhancing both energy efficiency and personal comfort. Curtailing room temperature to ambient temperature has significant positive impacts on energy conservation, greenhouse gas emission reduction, and economic savings. The automated system developed in this study demonstrates the feasibility and benefits of this approach. By adopting this practice on a larger scale, individuals and organizations can collectively enhance energy efficiency and environmental sustainability while maintaining personal comfort.

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